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ABSTRACT

Over the past few years, computer applications such as games and the Internet have increased in popularity and children and teens are spending significant amounts of time interacting with them. In order to understand the growing impact of these interactive technologies on youth, this paper briefly reviews previous research on the impact of computer use on children and adolescents. The Internet, and in particular recent trends in adolescent Internet use, is highlighted. Finally, the paper discusses research on the social and psychological impact of Internet use by adolescents and presents data from an ongoing study on the impact of adolescents Internet use on their loneliness. (Contains 15 references.) (Author/GCD)

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The Impact of Interactive Technology on Children's & Adolescents' Cognitive and Social Skills

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The Impact of Interactive Technology on Children's & Adolescents' Cognitive and Social Skills

Over the past few years, computer applications such as games and the Internet have increased in popularity and children and teens are spending significant amounts of time interacting with them. In order to understand the growing impact of these interactive technologies on our youth, I will start by briefly reviewing previous research on the impact of computer use on children and adolescents. Next, I will talk about the Internet, in particular focusing on recent trends in adolescent Internet use. Finally, I will discuss research on the social and psychological impact of Internet use by adolescents and will present data from an ongoing study on the impact of adolescents' Internet use on their loneliness

Previous Research on the Impact of Computer Use on Children and Adolescents

Computer games and the development of cognitive skills.

Researchers have suggested that computer applications, such as games, will have an impact on our cognitive sills because of the unique demands they place on users (e.g., Greenfield, 1994). For instance, with the advent of computer applications, there has been a shift in the emphasis of processing from verbal to visual. Furthermore, most action games are spatial, iconic, dynamic, and have things going on at different locations. Previous research on the cognitive impact of games has mostly focused on spatial, iconic, and attentional skills (for a recent review of this research see, Subrahmanyam, Greenfield, Kraut, & Gross, 2001).

Here, I will briefly review research on the impact of computer game playing on three cognitive skills - spatial representation, iconic skills, and visual attention. Spatial

representation is best thought of as a domain of skills rather than a single ability and comprises skills such as mental rotation, spatial visualization, and the ability to deal with two-dimensional images of a hypothetical two- or three-dimensional space. Such skills are central to a variety of computer applications, including programming and computer and video games. There is some evidence that repeated playing of applications (e.g., computer and video games) that utilize spatial skills may over time enhance the particular skills involved (e.g., Okagaki & Frensch, 1994; Subrahmanyam & Greenfield, 1994).

For instance in Subrahmanyam & Greenfield's study (1994), an experimental group of 10-1/2 to 11-1/2-year-olds received repeated practice on a computer game, Marble Madness, while the control group repeatedly played Conjecture, a computerized word game. Based on an analysis of Marble Madness, computerized pre- and post-test assessments of selected spatial skills (e.g., anticipating targets, extrapolating spatial paths) were obtained. The results revealed that the experimental group reliably improved spatial performance compared to the control group. It is important to remember however, that computer game playing is only likely to enhance those spatial skills utilized by the game and it is unclear whether game playing will result in across the board benefits to cognitive performance.

Iconic skills are another important cognitive skill utilized by computer applications such as games, word processing software, and the Internet. Iconic skill is the ability to "read" images, such as pictures and diagrams. In order to study whether playing a computer game would shift representational styles from verbal to iconic, Greenfield, Camaioni, et al. (1994) asked undergraduate students to play the game, *Concentration*, either on a computer or on a board. Students were then asked to describe

an animated computer simulation. Greenfield et al. found that the group that had played the game on the computer used more diagrams or icons and the group that played the game on the board used more verbal descriptions. The significance of these findings becomes obvious when one considers that both iconic and spatial representation are crucial to scientific and technical thinking and that they are both utilized in all kinds of computer applications.

A final cognitive skill that I will consider is that of visual attention, which is the skill of keeping track of a lot of different things at the same time. Greenfield, deWinstanley et al. (1994) measured college students' response time to two events of varying probabilities at two locations on a computer screen. They found that expert computer game players (as measured by self-reports) had faster response times than novices. More skilled video game players thus appeared to have better developed attentional skills than less skilled players.

The limited research on the question of cognitive effects of game playing has found that playing a specific computer game has immediate positive effects on specific spatial, iconic, and attentional skills used by that game. There have also been suggestions by Greenfield (1998) that recent documented increases in nonverbal or performance IQ may be related to the increased use of interactive technologies in the past decade. Indeed Greenfield has pointed out that many computer games seem to utilize the very same skills tested in the nonverbal sections of IQ tests such as the Wechsler and the Stanford Binet. For example, spatial visualization is utilized while playing the computer game, tetris, and is also tested in the Object Assembly subtests of the Wechsler intelligence tests.

Most of the research reviewed above is outdated given the recent advances in interactive technology. There is a pressing need for more research on the newer generation of games to understand the effects of both the medium (e.g., better graphics and hardware capabilities) and the content (increased sexual and aggressive themes). Furthermore, all the studies examined only the immediate effect of game playing and we really do not have any evidence on the cumulative impact of interactive games on cognition. Another concern is that although computers and the Internet are widely used by children for school work and to obtain information, there has been very little systematic research on the impact of home computer use on children's academic skills (Subrahmanyam, et al., 2001). Finally, we need more research to disentangle the relation between repeated computer game playing and the documented rise in nonverbal IQ performance.

Computer games and social skills

Research suggests that moderate game playing does not significantly impact children's social skills and relationships with friends and family either positively or negatively. For example, no difference has been found in the sociability and social interactions of computer game players versus non-players (Phillips, Rolls, and Rouse, 1995). Little is known about the long term effects of excessive computer use on children's social relationships.

Adolescents and the Internet

Internet use has grown among teenagers (Becker, 2000; UCLA Internet Report, 2001) and estimates of time use vary widely across studies. Teenagers use the Internet for both instrumental purposes, such as doing school work and finding educational

material and for social purposes, such as communicating with friends, meeting new people, and joining groups (Kraut, Patterson, Lundmark, Kiesler, and others, 1998). Gross et al. (2001) report that on average, adolescents (Mean Age = 12.11 years) spend the majority of their daily online time on instant messaging (28.85 minutes), visiting websites and surfing the web (24.45 minutes), and email (20.4 minutes).

Social Effects of Communicating via the Internet

Given the popularity of the Internet among teens for communication purposes such as email, chat rooms, and instant messaging, an important question is whether these social uses add to or diminish teenagers' repertoire of social skills/abilities? In order to address this question, data from three sets of studies will be presented here. First, I will revisit the results of the Original HomeNet Study (Kraut et al., 1998), the three-year-follow-up, and a subsequent longitudinal study conducted in 1998/1999 by Kraut, Kiesler, Boneva, and others (2001). Then I will present the results of the Gross, Juvonen, & Gable study (2001). Finally I will present the results of an ongoing study conducted in my lab (Subrahmanyam & Lin, 2002).

The HomeNet Studies. The HomeNet project was a field trial at Carnegie Mellon University, whose purpose was to understand household use of the Internet. One hundred and seven families and 302 individuals, including 113 children between the ages of 10 and 19 years were part of the trial. These families were provided with computers and access to the Internet and they were studied for two years through in-home interviews, periodic questionnaires, and automatically, whenever members of these families went online. The goal was to examine the factors influencing use of the Internet, the manner of such use, and the effect of such use over time.

During the first and second year of access, greater use of the Internet was associated with declines in teens' social involvement (communication within the family, size of social networks, and feelings of loneliness), increases in depression, and decline in social support (Kraut et al., 1998). During the next 12 months, further use of the Internet was associated with smaller declines in psychological and social well-being or even improvements. In a subsequent longitudinal study conducted in 1998 and 1999 (Kraut et al., 2001), the effect of Internet use was positive for size of local and distant social circles, amount of face-to-face communication, community involvement, trust in people, and positive affect. Heavier Internet use was associated with greater stress, less local knowledge, and lower desire to live in the local area. Apparently people with more social resources received more benefits from using the Internet leading the authors to suggest a "rich get richer" model of Internet use.

Gross, Juvonen, & Gable Study. There is some corroborative evidence that a more critical variable mediating online social effects might be who one interacts with on the Internet. In a recent study on 130 7th-graders, Gross et al. (2001) first asked participants to complete dispositional measures of well-being. Then on three days, they completed measures of daily well-being, after-school activity, and detailed logs of private Instant Message communication. Gross et al. reported that teens who on average reported more daily loneliness and/or social anxiety in school were more likely to communicate with a stranger than with a close friend after school.

Subrahmanyam & Lin study (2002). Next, I report on the results of an ongoing self-report study with a graduate student (Subrahmanyam & Lin, 2002), in which we examined the social effects of online use among a group of urban teens in Los Angeles

County. Our goal was to determine whether correlates of Internet use, such as the amount of time spent online, would be related to social-emotional well-being as measured by loneliness and perceived social support.

A total of 192 (94 males and 98 females) teens between 13- to 18-years of age (M = 16.1 years) participated. The sample was ethnically diverse with 38% White, 35.4% Asian (Asian, Asian-Indian, and Pacific Islander), 17.1% Hispanic, 1.6% African American, and 7.8 % Other. Participants completed the Internet Access Questionnaire which was developed by us, the Roberts revision of the UCLA Loneliness Scale (RULS), and Harter's Social Support Scale. Only the results of the Internet Access Questionnaire and the RULS are presented here.

The Internet Access Questionnaire consisted of questions on access to and use of (time spent per week, time spent per day, etc) the Internet. In addition, it also consisted of questions regarding the kinds of activities participants engaged in online (e.g., surfing, chatting, etc), who they interacted with online (strangers, offline friends, etc.), and whether they had interacted with their online acquaintances face-to-face. The RULS consisted of eight statements with a Likert-type response format; four statements were positive (I feel in tune with people around me) and four statements were negative (I lack companionship). For each statement, participants were asked to choose from one of four categories, *never* to *often,* with scores ranging from 0 for never to 3 for often, and total scores ranging from 0 to 24.

Preliminary analyses revealed no age, gender, or ethnic group differences with regard to access to a computer, home Internet access, and years/months of access. We did obtain a gender difference in the minutes online per week ($p < .05$), with boys

spending more time online than girls (See Figure 1). This finding is contrary to some early trends, which seemed to suggest that the Internet was helping to narrow the pervasive gender gap in computer use (Subrahmanyam, Kraut, Greenfield, & Gross, 2001).

The analysis of the RULS scores are based only on a sub sample of 142 (71 Males & 71 females) teens between 15 to 17 years of age. We were interested in assessing whether the total score on the RULS might be related to the actual amount of time spent online. To quantify the time spent online, we created the Internet use variable, with three levels of use - High (greater than 540 minutes/week), Medium (between 150 and 540 minutes/week) and Low (less than 150 minutes/week). The total score on the RULS was analyzed by a 2 X 3 (Gender X Internet use) between-subjects ANOVA. A main effect of gender ($p < .01$) was obtained; planned comparisons show that compared to girls, boys received higher scores on the RULS regardless of the amount of Internet use they reported (See Figure 2).

The above analysis suggested that one index of Internet use, the amount of time spent online, was not related to loneliness. We next conducted a multiple regression analysis to test whether other correlates of Internet use, such as being a new versus old Internet user and perceived closeness to online acquaintances/friends (e.g., speaking on the phone with an online acquaintance, approaching an online acquaintance in an emergency), would be related to loneliness. The variable to be predicted was the total score on the RULS; the predictor variables included gender (Male = 0, Female =1), new and old Internet user, Internet use group (Low, Medium, and High), whether a subject

had spoken on the telephone with an online acquaintance, and whether a subject would approach an online acquaintance in an emergency.

The regression analysis revealed that 25% of the variation in the total score on the RULS was accounted for by gender, telephoning an online acquaintance, and approaching an online acquaintance in an emergency (see Table 1). The analysis suggested that the total score on the RULS was significantly higher for respondents who were male, who reported speaking on the telephone with an online acquaintance, and who responded that they would approach an online acquaintance in an emergency; the other two variables (New and old user, Internet use group) entered into the regression were not significant. In sum, the Subrahmanyam and Lin Study revealed that in an urban ethnically diverse sample, teen boys spent more time online than girls. Importantly our study showed that teens' perception of loneliness was not related to the amount of time they spent online. Instead, their perceived closeness to their online partners was more predictive of loneliness.

Conclusion

To conclude, our review of previous research suggested that computer game playing has a positive impact on the cognitive skills utilized in the game. However, this research is seriously out of date as both the technology and its use (i.e., pervasiveness and frequency) have dramatically changed since the time of the early studies on this topic. Although the popularity of the Internet, particularly among adolescents, has raised questions regarding the social impact of online use, the findings of recent studies suggest that the amount of time spent online is not a critical factor in modulating the impact of

Internet use on social and psychological well-being. More important might be what one does online and ultimately the nature of one's online relationships.

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Table 1.

Summary of the Regression Analysis for Variables Predicting the Total Score on the RULS

Variable	Coefficient	t	p value
Constant	5.591	1.650	.105
Gender	-3.243	-2.902	.005*
New & Old Internet user	.997	.652	.517
Internet use group	-.450	-.664	.509
Telephone online acquaintance	.966	2.094	.041*
Approach Online acquaintance in an emergency	1.552	2.698	.009*

Note. Adjusted $R^2 = 0.25$

Figure Caption

Figure 1. Time spent online as a function of gender and age.

Figure 2. Total score on the RULS as a function of gender and Internet use.

Figure 1

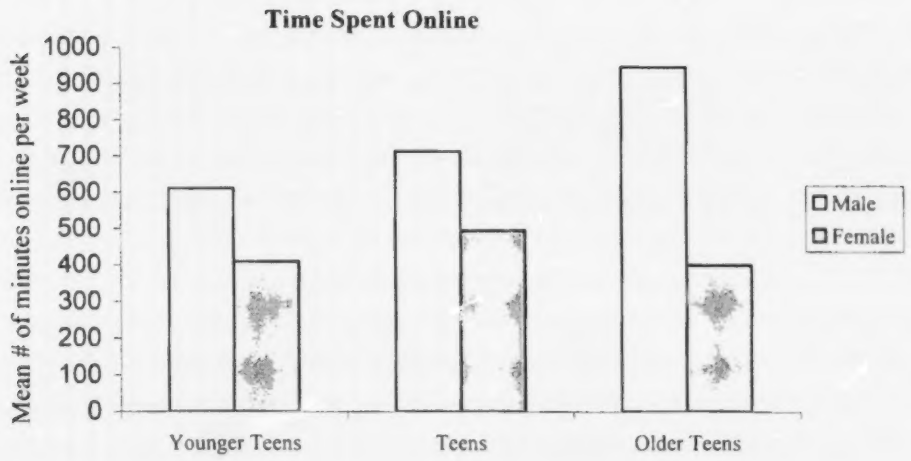
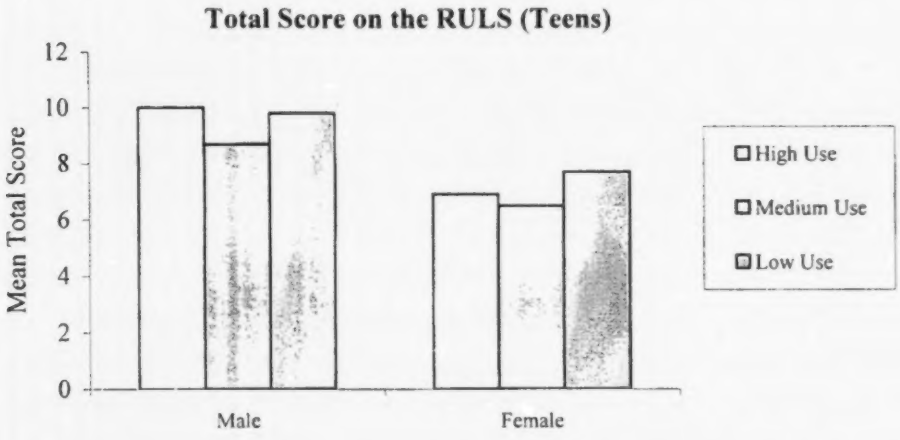

Time Spent Online
Mean # of minutes online per week
1000
900
800
700
600
500
400
300
200
100
0
Younger Teens
Teens
Older Teens
Male
Female

Figure 2


Total Score on the RULS (Teens)
Mean Total Score
12
10
8
6
4
2
0
Male
Female
High Use
Medium Use
Low Use

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